Gingival Recession Following Apical Surgery in the Esthetic Zone: A Clinical Study with 70 Cases

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Abstract

The present study evaluated gingival recession 1 year following apical surgery of 70 maxillary anterior teeth (central and lateral incisors, canines, and first premolars). A visual assessment of the mid-facial aspect of the gingival level and of papillary heights of treated teeth was carried out using photographs taken at pre-treatment and 1-year follow-up appointments. In addition, changes in the gingival margin (GM) and clinical attachment levels (CAL) were calculated with the use of clinical measurements, that is, pre-treatment and 1-year follow-up pocket probing depth and level of gingival margin. Changes in GM and CAL were then correlated with patient-, tooth-, and surgery-related parameters. The following parameters were found to significantly influence changes in GM and CAL over time: gingival biotype ($P < 0.05$), with thin biotype exhibiting more gingival recession than thick biotype; pre-treatment pocket probing depth (PPD) ($P < 0.03$), with cases of pre-treatment PPD < 2.5 mm demonstrating more attachment loss than cases of PPD ≥ 2.5 mm; and type of incision ($P < 0.01$), with the submarginal incision showing considerably less gingival recession compared with the intrasulcular incision, papilla-base incision or papilla-saving incision. The visual assessment using pre-treatment and 1-year follow-up photographs did not demonstrate significant changes in gingival level or papillary height after apical surgery. In conclusion, gingival biotype, pre-treatment PPD, and type of incision may significantly influence changes in GM and CAL following apical surgery in maxillary anterior teeth.
(Eur J Esthet Dent 2009;4:28–45)

Introduction

Apical surgery has made considerable progress in the last 20 years, mainly following the introduction of microsurgical principles, that is, the use of a surgical microscope and the application of refined root-end preparation techniques and obturation materials.[1] The assessment of the surgical outcome following apical surgery is based mainly on clinical and radiographic criteria of healing of periradicular tissues. In contrast, soft tissue (gingiva, alveolar mucosa) healing has received comparatively little attention, and much of the knowledge has been drawn from the periodontal literature.[2] However, apical surgery and periodontal surgery differ with regard to the nature of the treated lesions and the surgical approach.

Soft tissue healing following apical surgery may include gingival and papillary recession, and scar formation. Scar formation seldom is a functional or esthetic problem unless the patient has a high smile line. However, recession of the facial gingival margin and/or of the interdental papillae may compromise esthetics, in particular in the maxillary anterior region (esthetic zone). Loss of papillary height may also result in food impaction and disturbed phonetics.

Few clinical studies have addressed soft tissue changes following apical surgery. Jansson and co-workers[3] assessed changes in periodontal pocket depth and clinical attachment level (CAL), 1 year following apical surgery, comparing root-end resected (test) teeth with control teeth in the surgical area, and with contra-lateral control teeth. A full-thickness mucoperiosteal flap with vertical releasing incisions was raised, exposing the area around the test tooth and the two adjacent teeth. While the probing depth did not change across the three groups, loss of clinical attachment was more pronounced in root-end resected teeth compared with control teeth.

Velvart and co-workers[4] compared changes in papilla height 1 year after apical surgery with baseline height, performing an intrasulcular incision (ISI) with

Fig 1a Pre-operative photo of right maxillary central incisor (35-year-old male). A scar is visible in the alveolar mucosa following a previous incision for drainage. Dotted line indicates intrasulcular incision (ISI) used in subsequent apical surgery.

Fig 1b The 1-year follow-up photo shows a slight recession of the facial gingiva with root exposure at the right maxillary central incisor and a minimal shrinkage of the central papilla. A marked scar is visible in the alveolar mucosa distal to the lateral incisor (location of former release incision).

complete mobilization of one adjacent papilla, but using the papilla base incision (PBI) in the other interproximal space. At the 1-year follow-up, PBI sites showed no papilla shrinkage, whereas the papilla height in ISI sites had diminished by 1mm. The authors concluded that PBI allows predictable recession-free healing of the interdental papilla.

Other clinicians[5] evaluated periodontal changes following apical surgery, and assessed whether the observed changes correlated with the type of incision or type of restoration present at the gingival margin. Significant differences were found for changes in levels of gingival margin and clinical attachment when comparing the ISI and the submarginal (SMI) incisions. For example, ISI demonstrated a mean recession of 0.42 mm at buccal sites, whereas SMI yielded a gain of 0.05 mm at the 1-year follow-up. No statistically significant influence of the presence and type of restoration margins or the smoking habit of the patient could be demonstrated. The aims of the present clinical study were *(i)* to visually and clinically assess gingival recession following apical surgery and *(ii)* to evaluate if recession correlated with: patient-, tooth- or treatment-related parameters.

Materials and methods

From a pool of 493 consecutively treated and prospectively documented cases with apical surgery, 107 cases including 123 teeth with apical surgery (or re-surgery) performed in the esthetic zone were selected for the present study. The esthetic zone was defined as the anterior maxillary area, including incisors, canines and first premolars. A total of 37 patients with 53 teeth were excluded or could not be recalled for various reasons (Table 1). The final number of patients and teeth was 70.

Table 1 Reasons for exclusion and drop-out cases.

		Number of patients	Number of teeth
Initial material		107	123
Excluded	multiple teeth treated within same flap	15	31
	missing facial bone plate	6	6
	incomplete data set	11	11
Drop-outs	tooth extracted	2	2
	patient could not be located	1	1
	patient not willing to attend 1-year follow-up	2	2
Final material		70	70

Fig 2a Pre-operative photograph of left maxillary central incisor (68-year-old male). Dotted line indicates intrasulcular incision (ISI) used in subsequent apical surgery.

Fig 2b The 1-year follow-up photograph shows a slight recession of the facial gingiva, with exposure of the crown margin at the left maxillary central incisor. Shrinkage of the central papilla and a minimal recession of the facial gingiva at the left maxillary lateral incisor can also be observed.

Fig 3a Pre-operative photograph of right maxillary central incisor (15-year-old female). Dotted line indicates submarginal incision (SMI) used in subsequent apical surgery. The left central incisor is infrapositioned due to ankylosis following avulsion.

Fig 3b The 1-year follow-up photograph shows complete maintenance of the gingival margin and papillae of the right maxillary central incisor. Scarring of the attached gingiva is almost invisible. Note that the incisal restoration of the left central incisor has been replaced.

Fig 4a Pre-operative photograph of left maxillary first premolar (63-year-old female). Dotted line indicates submarginal incision (SMI) used in subsequent apical surgery.

Fig 4b The 1-year follow-up photograph shows a minimal recession of the facial gingiva of the first premolar. Scarring of the attached gingiva is also minimal, but more pronounced in the alveolar mucosa of the canine at the location of the former release incision.

Surgical technique

Patients were fully informed about the surgical procedure, postoperative care, follow-up examinations, and alternative treatment options. Each patient signed a consent form based on the principles defined in the declaration of Helsinki. All surgery was carried out by the same surgeon (TVA).

Apical surgery was performed under local anesthesia and with the use of a surgical microscope. Following elevation of a full-thickness mucoperiosteal flap, bone was removed from the apical area to gain access to the lesion and the root end. Affected roots were then resected approximately 3 mm from the apex. Following debridement of the pathologic tissue, hemostasis of the bony crypt was achieved. After the surgical area was stained with methylene blue, the root end was inspected for the presence of fractures, cracks or isthmuses using a rigid endoscope. Root-end cavities were prepared with sonic-driven microtips, and were retrofilled with either SuperEBA (Staident International, Staines, UK), or MTA (Mineral Trioxide Aggregate, Dentsply Tulsa Dental, Tulsa, OK, USA). Alternatively, a shallow concavity was prepared in the cut root face using round diamond burs, with subsequent placement of dentin-bonded resin composite (Retroplast, Retroplast Trading, Rorvig, Denmark). After the wound area had been cleaned, wound closure was accomplished with sutures, and gauze was applied for slight compression. All patients were given non-steroidal analgesics and were instructed to rinse with 0.1% chlorhexidine digluconate twice a day for 10 days. Antibiotics were not prescribed routinely. Sutures were removed 4 to 7 days after surgery. Patients were recalled 1 year postsurgically for clinical and radiographic re-examination.

Patient-, tooth-, and surgery-related parameters

The population data noted included age (<45 years, ≥ 45 years), gender (male, female), gingival biotype (thin-scalloped, thick-flat)[6], and smoking habit (yes, no). The type of tooth (maxillary central incisor, lateral incisor, canine, first premolar) and the presence of a restoration margin at the facial gingiva were also recorded. The periodontal parameters comprised probing pocket depth (PPD), level of gingival margin (GM), calculated clinical attachment level (CAL = PPD - GM), and indices of plaque and bleeding on probing.[5] Periodontal data were collected by means of a periodontal probe (Colorvue Tip, Hu-Friedy, Leimen, Germany) to the nearest 0.5 mm at mesio-buccal, mid-buccal, and disto-buccal sites, and were subsequently pooled for further analysis. The mean distance (at mesial and distal aspects) between the crestal bone level and the cementoenamel junction (CEJ) or restoration margin was assessed on peri-apical radiographs. The surgical parameters included: type of surgery (first-time surgery, re-surgery); type of incision (intrasulcular incision [ISI], submarginal incision [SMI], papilla base incision [PBI], papilla saving incision [PSI]. See figs 1 to 8)[7]; type of flap (trapezoidal, triangular-mesial, triangular-distal), and duration of surgery (< 60 minutes, ≥ 60 minutes).

Follow-up measurements

At the 1-year follow-up, measurements of the periodontal parameters were repeated, and changes over time were calculated to *(i)* determine the extent of gingival recession and loss of clinical attachment, and *ii)* correlate the computed changes with patient-, tooth-, and surgery-related parameters.

Fig 5a Pre-operative photograph of left maxillary central incisor (63-year-old female). Dotted line indicates papilla-base incision (PBI) used in subsequent apical surgery.

Fig 5b The 1-year follow-up photograph shows a minimal recession of the facial gingiva of both central incisors but maintenance of papilla heights. No scarring of the attached gingiva is visible.

Fig 6a Pre-operative photograph of left maxillary central incisor (62-year-old female). Dotted line indicates papilla-base incision (PBI) used in subsequent apical surgery. Note that crown margins are visible in both central incisors and also in the left lateral incisor.

Fig 6b The 1-year follow-up photograph shows a moderate recession of the facial gingiva of both left incisors with root exposure. No scarring of the attached gingiva is visible.

Fig 7a Pre-operative photograph of left maxillary central incisor (62-year-old female). A sinus tract is present in the alveolar mucosa at the disto-facial aspect of the left central incisor. Dotted line indicates papilla-saving incision (PSI) used in subsequent apical surgery.

Fig 7b The 1-year follow-up photograph shows a cleft-type recession of the facial gingiva of the left central incisor with root exposure. Scarring within the attached gingiva is also visible. Note that the sinus tract has disappeared.

Visual assessment

The visual assessment of the soft tissue changes was performed independently by three observers: a periodontist (GES) an oral surgery graduate student (SJ), and an oral and maxillofacial surgeon (SSJ). Each were provided with a PDF document with the photographs taken at the initial examination (pre-treatment photograph) and at the re-examination (1-year follow-up photograph). The photographs were taken with a digital camera (Nikon, D100, Nikkor Medical Objective and Macro Speedlight, Nikon Corporation, Tokyo, Japan). The observers had not been involved in the surgery, and were blinded to the type of incision and flap used. The only information disclosed to them was the tooth treated. They were trained and calibrated by means of sample photographs.

The level of mid-facial gingiva and height of mesial and distal papillae[8] (Table 2) were visually assessed. For each soft tissue parameter, a pre-treatment and a follow-up score were determined. The change (follow-up score minus pre-treatment score) was then computed and categorized as no change (score difference = 0), minor change (score difference 1) or substantial change (score difference 2). Positive values were defined as 'deterioration' and negative values as 'improvement'.

Statistics

In order to assess the inter-rater agreement, weighted kappa values were computed according to the procedure described by Fleiss and Cohen.[9] In addition, the concordance between each observer and the consensus was computed. For analysis of comparison of pretreatment and 1-year follow-up scores, Bowker's test for symmetry was performed.[10] In order to

Table 2 Definition of scores used for visual assessment of level of mid-facial gingiva and height of interdental papillae

Score	Level of mid-facial gingiva	Height of interdental papilla[8]
0	level is coronal to CEJ*	papilla completely fills embrasure space
1	level is at CEJ	papilla tip lies between interdental contact point and most coronal extent of interproximal CEJ
2	level is apical to CEJ	papilla tip lies at or apical to interproximal CEJ but coronal to apical extent of facial CEJ (interproximal CEJ visible)
3	–	papilla tip lies level with or apical to facial CEJ

CEJ: cementoenamel junction. (In case of a restoration, the gingival margin of the restoration was used for assessment).

Table 3 Range of computed kappa values (inter-rater agreement, and concordance between observer and consensus) for scoring of level of mid-facial gingiva and levels of mesial and distal papillae (n = 70)

		Kappa values for rating of mid-facial gingiva	Kappa values for rating of mesial papilla	Kappa values for rating of distal papilla
Pre-treatment	inter-rater agreement	0.48–0.73	0.68–0.71	0.56–0.68
	concordance between observer and consensus	0.67–0.89	0.82–0.87	0.82–0.86
1-year follow-up	inter-rater agreement	0.54–0.67	0.66–0.72	0.56–0.67
	concordance between observer and consensus	0.73–0.87	0.78–0.89	0.74–0.89

Interpretation of Kappa values: 0.00 poor agreement, 0.01–0.20 slight agreement, 0.21–0.40 fair agreement, 0.41–0.60 moderate agreement, 0.61–0.80 substantial agreement, 0.81–1.00 almost perfect agreement.[9]

Table 4 Visual scoring of pre-treatment and 1-year follow-up level of mid-facial gingiva (n = 70)

Score	Pre-treatment		1-year follow-up	
0 (level is coronal to CEJ)	6	8.6%	4	5.7%
1 (level is at CEJ)	20	28.6%	17	24.3%
2 (level is apical to CEJ)	44	62.9%	49	70.0%

The difference between visual pre-treatment and 1-year follow-up scores of the level of the mid-facial gingiva was not significant ($P = 0.1344$).
CEJ: cementoenamel junction. (In case of a restoration, the gingival margin of the restoration was used for assessment).

detect if the distribution of the calculated changes was different at the mid-facial gingiva level and for mesial and distal papillae, pairwise Wilcoxon signed rank tests were performed. Fisher's exact test was used to determine if the type of incision had any influence on the visually assessed change per site. With regard to the clinical measurements, Wilcoxon's rank sum test (Kruskal-Wallis test for parameters with more than two subgroups) was performed to determine whether or not the population data as well as the tooth-related and surgical parameters had an impact on the change of GM and CAL. Due to the explorative nature of the study, no *P* value adjustment for multiple testing was performed. All analyses were carried out with the use of SAS version 9.1 (SAS Institute, Cary, NC, USA).

Results

Kappa values of inter-rater agreement ranged from 0.48 to 0.73 and concordance between each examiner and the consensus ranged from 0.67 to 0.89. Pairwise comparisons between the three examiners were rated as moderate to substantial, and a substantial to almost perfect concordance was found between examiner and consensus ratings (Table 3).

With regard to the visual assessment, the pre-treatment level of the mid-facial gingiva was found to be apical to the CEJ (or in case of a restoration, apical to the facial restoration margin) in 62.9% of the cases, and this number increased to 70% ($P > 0.1$) at the 1-year follow-up (Table 4). With regard to the pre-treatment height of the interdental papillae, 62.9% of mesial papillae and 64.3% of distal papillae were rated as incomplete (Table 5). Percentages of incomplete papillae at the 1-year follow-up were 67.1% (mesial) and 61.4% (distal), respectively. Differences in papilla heights comparing either pre-treatment and follow-up scores, or mesial and distal papillae, were not statistically significant ($P > 0.5$).

The majority of cases remained unchanged with regard to the visual assessment of the mid-facial level of the gingiva (87.1%), the height of the mesial papilla (84.3%), and the height of the distal papilla (92.9%) (Table 6). A substantial loss of tissue height was not observed in any case, and 5.7% of mesial papilla showed a minor improvement in papillary height.

Table 5 Visual scoring of pre-treatment and 1-year follow-up height of mesial and distal papillae (n = 70)

	Height of mesial papilla				Height of distal papilla			
Score	**pre-treatment**		**1-year follow-up**		**pre-treatment**		**1-year follow-up**	
0 (complete papilla)	11	15.7%	8	11.4%	11	15.7%	10	14.3%
1 (incomplete papilla)	44	62.9%	47	67.1%	45	64.3%	43	61.4%
2 (interproximal CEJ visible)	14	20.0%	14	20.0%	14	20.0%	16	22.9%
3 (papilla level or apical to facial CEJ)	1	1.4%	1	1.4%	0	0%	1	1.4%

The differences between visual pre-treatment and 1-year follow-up scores of the height of the mesial and distal papillae were not significant ($P = 0.9724$ and $P = 0.5438$, respectively).
CEJ: cementoenamel junction. (In case of a restoration, the gingival margin of the restoration was used for assessment).

Table 6 Categorization of visual assessment of changes in mid-facial gingiva level and papilla heights (n = 70)

	Level of mid-facial gingiva		Height of mesial papilla		Height of distal papilla	
No change (+0)	61	87.1%	59	84.3%	65	92.9%
Minor deterioration (+1)	8	11.4%	7	10.0%	5	7.1%
Substantial deterioration (+2)	0	0%	0	0%	0	0%
Minor improvment (-1)	1	1.4%	4	5.7%	0	0%
Substantial improvment (-2)	0	0%	0	0%	0	0%

No significant differences were found for the distribution of scores comparing the mid-facial gingiva to the mesial papilla ($P = 0.4807$), comparing the mid-facial gingiva to the distal papilla ($P = 0.7744$), and comparing the mesial to the distal papilla ($P = 0.7949$).

However, changes were not found to be statistically significant ($P > 0.4$) with pairwise comparison of the assessed sites. The evaluation of the frequency distribution of cases with deterioration per site with regard to the type of incision (Table 7) showed a borderline significant influence for the mid-facial gingiva level ($P = 0.0613$), but no significant influence for the papilla height ($P > 0.05$).

One year after apical surgery, the overall clinically measured mean recession of the facial gingival margin (GM) was -0.20 mm (± 0.35 mm), and the mean loss of CAL was 0.09 mm (± 0.43 mm). Changes in GM and CAL with regard to the population data are shown in Table 8; biotype proved to be significant with regard to changes in GM ($P = 0.0458$). A thin biotype led to significantly more gingival recession (-0.32 mm) than a thick biotype (-0.08 mm). Age, gender and smoking appeared to have no significant influence on changes of GM and CAL.

Changes in GM and CAL with regard to tooth-related factors are shown in Table 9. The only tooth-related factor with a significant influence on the change in CAL was the pre-treatment pocket probing depth (PPD), that is, cases with baseline PPD < 2.5 mm had significantly more attachment loss (+0.26 mm change in CAL) than cases with baseline PPD of 2.5 to 3.5 mm (-0.03 mm change in CAL). There was a similar tendency for gingival recession to be more pronounced in cases with baseline PPD < 2.5 mm (-0.31 mm change in GM) than in cases with base-

Table 7 Frequency distribution of cases with deterioration (n=20) per site with regard to type of incision (n = 70)

	Level of mid-facial gingiva (n=8)		Height of mesial papilla (n=7)		Height of distal papilla (n=5)	
ISI (n=11)	3	27.3%	3	27.3%	1	9.1%
SMI (n=30)	1	3.3%	1	3.3%	1	3.3%
PBI (n=21)	2	9.5%	3	14.3%	2	9.5%
PSI (n=8)	2	25.0%	0	0%	1	12.5%

The type of incision had a borderline significant influence on the level of the mid-facial gingiva (P = 0.0613), but no significant influence on the height of the mesial (*P* = 0.0975) or distal (*P* = 0.4905) papillae.

Table 8 Mean computed metric changes (± standard deviation of means) of level of gingival margin (GM) and calculated attachment level (CAL) over observation period in relation to population data (n = 70).

Population data	Subgroups	n	Change (mm) in GM*	Change (mm) in CAL**
Age	< 45 years	25	-0.19 (± 0.33)	+0.15 (± 0.37)
	≥ 45 years	45	-0.21 (± 0.36)	+0.05 (± 0.45)
	P value		0.8299	0.2050
Gender	Male	31	-0.26 (± 0.40)	+0.20 (± 0.47)
	Female	39	-0.16 (± 0.29)	-0.01 (± 0.39)
	P value		0.4637	0.2325
Smoking	no	61	-0.21 (± 0.35)	+0.08 (± 0.44)
	yes	9	-0.17 (± 0.33)	+0.13 (± 0.33)
	P value		0.7188	0.7522
Biotype	Thin	37	-0.32(± 0.33)	+0.17 (± 0.48)
	Thick	33	-0.08(± 0.34)	-0.01 (± 0.37)
	P value		0.0458 (sign***)	0.3304

*GM = gingival margin (negative values = recession, positive values = 'inflation')
**CAL = clinical attachment level (positive values = loss of attachment; negative values = gain of attachment).
*** = significant at the usual significance level of 0.05

Table 9 Mean computed metric changes (± standard deviation of means) of level of gingival margin (GM) and calculated attachment level (CAL) over observation period in relation to tooth factors (n = 70)

Parameter	Subgroups	n	Change (mm) in GM*	Change (mm) in CAL**
Type of tooth	Maxillary central incisor	31	-0.27 (± 0.31)	+0.07 (± 0.41)
	Maxillary lateral incisor	20	-0.10 (± 0.43)	+0.03 (± 0.45)
	Maxillary canine	4	-0.25 (± 0.25)	+0.33 (± 0.33)
	Maxillary first premolar	15	-0.19 (± 0.32)	+0.13 (± 0.45)
	P value		0.4804	0.7392
Restoration margin	No	13	-0.19 (± 0.51)	+0.24 (± 0.61)
	Yes	57	-0.21 (± 0.31)	+0.05 (± 0.38)
	P value		0.7280	0.4421
Pre-treatment pocket probing depth (PPD)	< 2.5 mm	27	-0.31 (± 0.34)	+0.26 (± 0.43)
	2.5–3.5 mm	43	-0.14 (± 0.34)	-0.03 (± 0.39)
	> 3.5 mm	0	N/A	N/A
	P value		0.0929	0.0279 (sign***)
Pre-treatment level of gingival margin (GM)	Below CEJ or below restoration margin	40	-0.18 (± 0.31)	+0.07 (± 0.43)
	At CEJ or at restoration margin	12	-0.20 (± 0.26)	+0.02 (± 0.27)
	Above CEJ or above restoration margin	18	-0.27 (± 0.48)	+0.18 (± 0.53)
	P value		0.7462	0.8362
Pre-treatment level of clinical attachment (CAL)	< 2 mm	15	-0.26 (± 0.34)	+0.22 (± 0.44)
	2–3 mm	44	-0.18 (± 0.28)	+0.00 (± 0.33)
	3 mm	11	-0.23 (± 0.60)	+0.24 (± 0.70)
	P value		0.9155	0.3265
Pre-treatment radiographic bone level	< 2 mm	12	-0.04 (± 0.32)	-0.06 (± 0.37)
	2–3 mm	39	-0.20 (± 0.33)	+0.06 (± 0.41)
	> 3 mm	19	-0.32 (± 0.38)	+0.22 (± 0.47)
	P value		0.2372	0.3833

*GM = gingival margin (negative values = recession, positive values = 'inflation')
**CAL = clinical attachment level (positive values = loss of attachment; negative values = gain of attachment)
***sign = significant at the usual significance level of 0.05

line PPD of 2.5 to 3.5 mm (-0.14 mm change in GM).

Changes in GM and CAL with regard to surgery-related factors are presented in Table 10. The only surgical factor to show a significant change in GM was the type of incision ($P = 0.0079$). Considerably more gingival recession was found for PSI (-0.44 mm change in GM), for ISI (-0.35 mm change in GM) and for PBI (-0.35 mm change in GM) compared with SMI (+0.01 mm change in GM). A similar, but not significant tendency ($P = 0.0991$) was observed for the change in CAL with regard to the type of incision. In contrast, type and duration of surgery, as well as type of flap, had no effect on changes in GM and CAL.

Discussion

The present study evaluated gingival recession 1 year following apical surgery in 70 subjects. A visual assessment of the mid-facial aspect of the gingiva level and of papillary heights of treated teeth was carried out on photographs taken at pretreatment and 1-year follow-up appointments. In addition, changes in gingival margin GM and CAL were calculated with the use of clinical measurements, i.e., pretreatment and 1-year follow-up PPD and level of gingival margin. Changes in GM and CAL were then correlated with patient-, tooth-, and surgery-related parameters.

Marginal tissue recession, i.e., displacement of the gingival margin in an apical direction, may be related to nonsurgical (orthodontics or sub-gingival crown preparations) or surgical (flap procedures) interventions. Other causative factors include continuous mechanical trauma (predominantly tooth-brushing) and localized plaque-induced inflammatory lesions. In the present study, none of the treated teeth presented with wedge-shaped cervical defects, which would be indicative of tooth-brushing trauma. The overall oral hygiene of the treated teeth was excellent (baseline mean plaque-in-

Fig 8a Pre-operative photo of left maxillary central incisor (29-year-old female). Scarring and reddening are visible in the apical alveolar mucosa of the left central incisor that had undergone previous apical surgery. Dotted line indicates papilla-saving incision (PSI) used in subsequent apical surgery.

Fig 8b The 1-year follow-up photo shows a minimal recession of the facial gingiva of the left central incisor, with minimal exposure of the crown margin. New scars within the attached gingiva and across the frenulum are visible. Note that the pre-operative reddening has disappeared.

Table 10 Mean computed metric changes (± standard deviation of means) of level of gingival margin (GM) and calculated attachment level (CAL) over observation period in relation to surgical factors (n = 70).

Parameter	Subgroups	n	Change (mm) in GM*	Change (mm) in CAL**
Type of surgery	First-time surgery	61	-0.19 (± 0.33)	+0.08 (± 0.45)
	Re-surgery	9	-0.31 (± 0.17)	+0.15 (± 0.25)
	P value		0.3809	0.6738
Type of incision	ISI	11	-0.35 (± 0.15)	+0.24 (± 0.37)
	SMI	30	+0.01 (± 0.36)	-0.11 (± 0.42)
	PBI	21	-0.35 (± 0.37)	+0.21 (± 0.48)
	PSI	8	-0.44 (± 0.35)	+0.25 (± 0.27)
	P value		0.0079 (sign***)	0.0991
Type of flap	Trapezoidal	16	-0.25 (± 0.32)	+0.06 (± 0.40)
	Triangular-mesial	38	-0.24 (± 0.36)	+0.17 (± 0.44)
	Triangular-distal	16	-0.08 (± 0.36)	-0.09 (± 0.43)
	P value		0.5931	0.3039
Duration of surgery	< 60 minutes	31	-0.23 (± 0.34)	+0.12 (± 0.39)
	≥ 60 minutes	39	-0.18 (± 0.35)	+0.06 (± 0.45)
	P value		0.5041	0.3702

* GM = gingival margin (negative values = recession, positive values = 'inflation')
** CAL = clinical attachment level (positive values = loss of attachment; negative values = gain of attachment)
***= significant at the usual significance level of 0.05

dex: 0.11 ± 0.19, mean bleeding-on-probing index: 0.31 ± 0.50) and remained excellent (follow-up mean plaque-index: 0.04 ± 0.07, mean bleeding-on-probing index: 0.31 ± 0.30). None of the teeth underwent orthodontic treatment during the observation period.

The visual assessment using pre-treatment and 1-year follow-up photographs did not demonstrate significant changes in gingival level or papillary heights after apical surgery. The visual scoring system appeared to be inadequate for detection of minor changes of tissue recession compared with linear measurements with defined reference points. For example, Velvart and co-workers[11] used pre- and post-treatment study casts (alginate impressions of surgical sites) to evaluate papilla healing following apical surgery. The plaster casts were analyzed using a laser scan 3D device. For each patient, a reproducible point was chosen, and the distance from this point to the highest point of the papilla was measured.

In the present study, an interesting finding of the visual assessment was that 62.9% of cases already presented with a gingival margin that was located apical to the cementoenamel junction (or restoration margin). It can be speculated that these patients would not complain about additional recession. However, patients' attitudes toward esthetics were not assessed in the present study. 81.4% of the treated teeth had a long-term crown restoration (> 3 years). Valderhaug and Birkeland[12] reported that percentages of crown margins located supra-gingivally (19%) or at the gingival margin (16%) at delivery of the crown increased to 30% and 29%, respectively, within 5 years.

Clinical measurements of pre-treatment and 1-year follow-up periodontal parameters showed some interesting correlations between changes in GM or CAL and patient-, tooth-, or surgery-related parameters.

Patient-related factors

Age and gender appeared to have no influence on changes in GM and CAL. Nor did smoking exhibit any significant effect on changes in GM and CAL during the 1-year observation period. In a recent study about predictors for healing outcome after apical surgery, healing did not differ significantly in smokers and non-smokers.[13] The only patient-related factor to significantly influence the change in GM (but not in CAL) was the biotype. More substantial gingival recession was noted in thin biotype cases compared with thick biotype cases. Olsson and Lindhe[6] demonstrated that subjects with long, narrow teeth had a comparatively thin periodontium and were more susceptible to gingival recession than subjects who had a thick periodontal biotype. They also reported that the buccal gingival margin in thin biotype subjects was found to be about 1 mm more apical than in thick biotype subjects ($P < 0.05$). Also, Claffey and Shanley[14] reported that sites with thick gingiva (≥ 2 mm) displayed a less noticeable mean loss of clinical attachment compared with sites with thin gingiva (≤ 1.5 mm) following non-surgical periodontal therapy.

Tooth-related factors

The type of tooth and the presence or absence of a restoration margin had no effect on changes in GM and CAL. In contrast to Valderhaug and Birkeland's study,[12] in which GM changes were noted over a period of 5 years in patients with fixed restorations, the observation period in the present study was limited to 1 year. With regard to the baseline periodontal parameters, a significant effect on change in CAL was found for baseline probing pocket depth (PPD). Interestingly, the shallower the initial PPD, the more attachment loss observed. An explanation for this finding might be that thin biotype cases (with a mean baseline PPD of 2.45 mm) demonstrated significantly more gingival recession (see above) compared with thick biotype cases (with a mean baseline PPD of 2.62 mm), resulting in greater attachment loss overall. None of the other evaluated tooth-related factors proved to have a significant influence on changes in GM and CAL.

Surgery-related factors

The type of incision was the only surgical factor to significantly affect the change in GM ($P = 0.008$), and showed a tendency to affect change in CAL ($P = 0.0991$) over the observation period of 1 year. No gingival recession (GM change + 0.01 mm) was observed when a submarginal incision (SMI) had been used, compared with recession of between -0.35 mm and -0.44 mm with the other incision techniques (ISI, PBI, PSI). With regard to changes in clinical attachment level, ISI, PBI and PSI all produced a mean loss of attachment, ranging from 0.21 mm to 0.25 mm. In contrast, cases with a submarginal incision (SMI) showed a mean gain of attachment of 0.11 mm. It is plausible that the SMI prevents gingival recession, as it is the only incision technique (of the four applied incision techniques) that does not expose the marginal supporting structures. Chindia and Valderhaug[15] reported no statistically significant changes in pocket depth or attachment level when comparing a trapezoidal flap (with an intrasulcular incision, n = 10) to a semilunar flap (with a submarginal incision, n = 10). In contrast to the present study, extended flap designs were used which terminated bilaterally in the area of the maxillary second premolars (for apical surgery of a single anterior tooth).

The type of surgery (first-time surgery or re-surgery) and the duration of surgery appeared to have no effect on gingival recession or attachment loss in the present study. The effect of duration of surgery was evaluated in an experimental dog study by Levin and co-workers.[16] Partial- and full-thickness flaps were raised in the facial gingiva, and were reflected for 15 or 90 minutes. Flaps reflected for 15 min exhibited faster epithelial closure than those reflected for 90 min. Partial-thickness flaps reflected for both 15 and 90 min showed less inflammation than full-thickness flaps and healed faster with respect to epithelial closure, connective tissue healing, and bone regeneration. The shortest duration of apical surgery in the present study was 40 min, and this surgery length might explain why no differences were seen with regard to changes in GM and CAL, even when dichotomizing cases into two groups (cut-off time limit at 60 min). Irrespective of the type of flap design, flap design was not found to significantly influence the changes in GM and CAL. Pini Prato and co-workers[17] designed a clinical study to measure the tension of coronally advanced flaps performed to treat shallow gingival recessions, and to compare the recession reduction of flaps with and without tension. They reported that the higher the flap tension, the lower the recession reduction. The fact that the flap design in the present study did not affect changes in GM and CAL might be explained by the fact that in apical surgery, the flap is normally not coronally advanced and flap tension might be negligible.

Conclusions

The mean recession of the facial gingival margin in maxillary anterior teeth 1 year after apical surgery was -0.20 mm (± 0.35 mm) compared with the pre-treatment level.

The mean loss of calculated attachment level was 0.09 mm (±0.43 mm).

A thin biotype led to significantly ($P < 0.05$) more gingival recession (-0.32 mm) than a thick biotype (-0.08 mm).

Cases with a pre-treatment PPD < 2.5 mm had significantly ($P < 0.03$) more attachment loss (+0.26 mm change in CAL) than cases with a baseline PPD ≥2.5 mm.

A submarginal incision (+ 0.01 mm change in GM) resulted in significantly ($P < 0.01$) less gingival recession than an intrasulcular (-0.35 mm), a papilla-base (-0.35 mm), or a papilla-saving incision (-0.44 mm).

The visual assessment using pre-treatment and 1-year follow-up photographs did not demonstrate significant changes in gingival level or papillary heights after apical surgery.

Acknowledgements

The authors thank Dirk Klingbiel, Rahel Studer and Gabriel Fischer, Institute of Mathematical Statistics and Actuarial Science (IMSV), University of Bern, for the statistical analysis.

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